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Standards & Protocols

ADSL Frame Formats – Digital Delivery

ADSL technology can be used to transport a variety of services including IP networking and voice and video transmission. This month's column delves into such mechanisms as data framing and bearer channel transport, shedding some light on the versatility of ADSL.

By Mike Rodbell

As a link layer access technology, ADSL provides a set of mechanisms to organize the presentation of information throughout the network. With its roots firmly planted in the telecommunication corner of the world, it should come as no surprise that ADSL formats the information in a streaming, synchronous, framed organization. Many of the terms used to describe the digital transport format come from the already well-defined world of the digital tele-phony networks such as T1, E1, SONET, and SDH.

Bearer channels

Following the lead of telecommunication protocols, the ADSL link services can support one or more bearer channels. Each of these channels can be used to transport different streams or flows of information. The number of channels provided in each interface is largely dependent on the rate at which the channel is capable of operating.

ADSL has two general types of bearer channels — AS and LS. The AS bearer channels carry traffic downstream to the customer premises. As many as four separate AS channels can exist: AS0, AS1, AS2, and AS3. The LS bearer channels are full duplex, carrying information in both the upstream and downstream directions. There can be as many as three LS channels, numbered from LS0 through LS2. Any bearer channel can operate at a multiple of 32 kbps up to the maximum rate carried by the particular interface.

While the number of channels carried can vary, AS0 is always supported. The remaining channels are optional, largely depending on the transport class.

These transport classes are selected based on the data rate and the configuration of bearer channels on the referenced link. There are four separate transport classes, along with a set of optional classes intended for European applications that use the 2.048-Mbps E-class carrier systems. The four primary classes are as follows:

- *Transport class 1.* Intended for short loops where high data rates are available, transport class 1 provides as much as 6.144 Mbps of traffic downstream to the end consumer. Transport class 1 can consist of between one and four bearer channels. This class is considered mandatory and must be able to support a single subchannel that runs at 6.144 Mbps in AS0. Transport class 1 also includes a series of optional channel configurations, which include:
  - One 4.608-Mbps and one 1.536 Mbps bearer channel
  - Two 3.072-Mbps bearer channels
  - One 3.072-Mbps and two 1.536-Mbps bearer channels
  - Four 1.536-Mbps bearers
- *Transport class 2.* This class is optional and provides 4.608-Mbps downstream capacity that can be built on the basis of up to three 1.536-Mbps channels. Thus, AS0, AS1, and AS2 can appear in transport class 2, depending on the particular configuration.
- *Transport class 3* . This class is also optional, and can carry as much as 3.072 Mbps downstream. As in the case of transport class 2, the bearer channels must be even multiples of 1.536 Mbps. This leaves two options for the bearer channels: one 3.072-Mbps bearer channels or two 1.536-Mbps bearer channels.
- *Transport class 4.* This class is mandatory, and consists of a single 1.536-Mbps channel.

As you may have noticed, this set of channel arrangements is entirely based on a least common denominator of the American Standard T-1 fundamental data rate. A number of optional transport classes are defined to accommodate the European standards. These optional transport classes include:

- *Transport class 2M-1.* This class provides a maximum rate of 6.144-Mbps as in the case of transport class 1, but divides the rate into collections of 2.048 Mbps, which can include:
  - One 6.144-Mbps channel

  - One 4.096-Mbps and one 2.048-Mbps downstream channel
  - Three 2.048-Mbps channels

- *Transport class 2M-2.* Like transport class 2, transport class 2M-2 provides 4.096 Mbps. It can be arranged into one 4.096-Mbps channel, or two 2.048-Mbps channels.
- *Transport class 2M-3.* This class can consist of a single 2.048- Mbps channel.

To further confuse matters, there are four additional transport classes to support ATM. In these classes, a single bearer channel AS0 can run at 1.760 Mbps, 3.488 Mbps, 5.216 Mbps, or 6.944 Mbps. These rates are based on ATM standards and have been selected to help ensure compatibility with ATM transport mechanisms not based on DSL.

In addition to the downstream traffic, a range of mechanisms is specified to support the transfer of control information and upstream data. There are two general additional types of channels: the C channel, which is a mandatory control channel, and up to two bidirectional bearer channels referred to as LS1 and LS2. The C channel always runs at 64 kbps.

The ADSL standards help provide order in the presence of this collection of options. Each of the transport classes not only specifies the number of downstream bearer channels, but also contains a standard set of configurations for the bidirectional channels (LS1 and LS2), and the C channel configuration.

Framing the Data

As in the case of any data transport mechanism, some mechanisms must be provided to synchronize the format and delivery of the digital information. With a standard information format that accommodates the needs of the data transport users as well as synchronous, time-dependent users, ADSL is no exception.

In ADSL, information is organized into a time-synchronized hierarchy. The data in the ADSL transport is organized into the following items:

- *Superframes.* These represent the highest level of data presentation and repeat every 17 ms. Each superframe contains sixty-eight ADSL frames, one of which is used to provide superframe synchronization, identifying the start of a superframe. Some of the remaining frames are also used for special functions.
- *Frames.* Each frame starts on a 250-ms time boundary. While the timing of the frames remains constant, the actual size and contents of the frames can vary on the basis of the

prevailing transport mode.

Both the frames and superframes have an inherent organization, providing structure to synchronize the information transport and manage the distribution of the various bearer channels.

Each ADSL frame is transmitted in a fixed format, as shown in Figure 1 . Each frame has three general sections:

- *The fast byte.* This is used for special superframe-related processing functions.
- *The fast data*. This is used for the transmission of time-sensitive information such as audio. To help ensure the accuracy of the fast data (remember, this is information transmitted with no time for retransmission), forward error correction (FEC) can also be used.
- *The interleaved data.* This is the user data that the ADSL interface is responsible for transmitting. This segment of the ADSL frame is typically used as the mechanism to transport data network (Internet, for example) payload.

Because each frame must be re-sent on 250-ms boundaries and the data rates can vary, the amount of information contained in each of the fast data and interleaved data portions of the basic frames will also vary. Additionally, all nonsynchronization frames are scrambled for transmission to help ensure that all superframe synchronization frames are unique.

The sixty-eight frames contained within the superframe are used to carry data, synchronize the frame organization, and perform special link maintenance functions. Superframe synchronization is achieved using the sixty-eighth frame, which contains no user data and only a synchronization pattern. This synchronization is important when you consider that some of the remaining frames are used for error detection and control signaling.

The fast data byte carries different information in the various frames within the superframe. The fast data bytes in the specific superframe frames include:

- The fast data byte of frame 0 contains cyclic redundancy check (CRC) information that is used to ensure the accuracy of the additional superframe control information.
- The fast data byte of frames 1, 34, and 35 contain indicator bits that are used for link control signaling. Some of these indicators include:
- Far end block error (FEBE) is used to signal a received mismatch of the data and received CRC.
-

Far end correction code (FECC) is used to signal the occurrence of data received with errors detected and/or corrected with the FEC.

- Loss of signal (LOS) is used to indicate the loss of reception of a quality pilot signal. This loss of reception is signaled through negative logic, with a zero indicating that an LOS condition has occurred, and one when all is well (at least with regard to LOS)
- Remote defect indication (RDI) signal is issued when a station receives one or more severely errored frames (SEF). In the ADSL context, a SEF occurs when two consecutive superframes are received in error.
- Frames 2 through 33 and 36 through 67 (the remaining frames) have fast data bytes that contain portions of an embedded operations channel (EOC) and synchronization control.

These bytes are used to provide link control and operations services required in alarm and fault surveillance. Some of these functions have considerably more detail. For example, the operations of the EOC and synchronization control fields are extremely complex.

Bearer channel transport

Now that we've covered the combinations of bearer channels and the basic transport mechanisms, the basics of the approaches used to transport user traffic over the ADSL frame structure are the next consideration. In isolation, the data mappings of the bearer channels to the superframe format are relatively straightforward. The mappings are complicated by the fact that several line rates can be supported on a channel, given the equipment and line configurations at the time of transmission.

The actual format and mapping of the user data onto the ADSL frames follows some basic structural algorithms. Pieces of information from each of the supported bearer channels are alternatively encapsulated within the basic frames. While the size of the data fragments varies on the basis of the particular transport class and mode, the sequencing of the data fragments follows a fixed pattern of AS0, AS1, AS2, AS3 LS0 (C channel), LS1, and LS2.

The mechanisms we've covered this month form the basis of how ADSL can be used to transport customer data. There is a broad range of services that can be pro- vided over the ADSL transport including IP networking, voice, and video transmission.

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Illustrations

Figure 1

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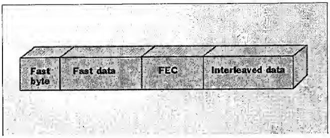

Figure 1: ADSL frame format.

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